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(54) **ELECTRONIC DEVICE AND POWER MANAGEMENT METHOD THEREOF**

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(51) **Int. Cl.**

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| ***G06F 1/30*** | (2006.01) |
| ***G06F 1/32*** | (2006.01) |

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CPC ..... ***G06F 1/30*** (2013.01); ***G06F 1/324*** (2013.01); ***G06F 1/3212*** (2013.01); *Y02B 60/1217* (2013.01); *Y02B 60/1292* (2013.01)

(58) **Field of Classification Search**

CPC ..... G06F 1/3234; G06F 1/3212; G06F 1/30
USPC ..... 713/323
See application file for complete search history.

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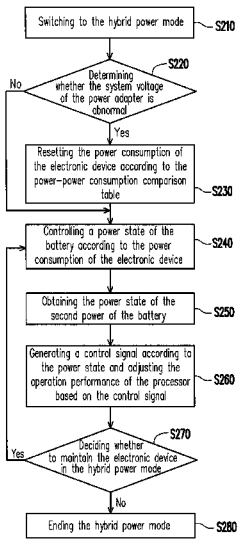
(57) **ABSTRACT**

A power management method is suitable for an electronic device including a controller, a processor and a battery, and includes following steps. A first power is provided to the electronic device by a power adapter, and a maximum value of the first power is smaller than a maximum value of a rated consumed power of the electronic device. A power state of a second power of the battery is obtained by the controller. A control signal is generated according to the power state, and the processor adjusts an operation performance of the processor based on the control signal. The operation performance of the processor is continuously adjusted according to the power state.

**27 Claims, 5 Drawing Sheets**



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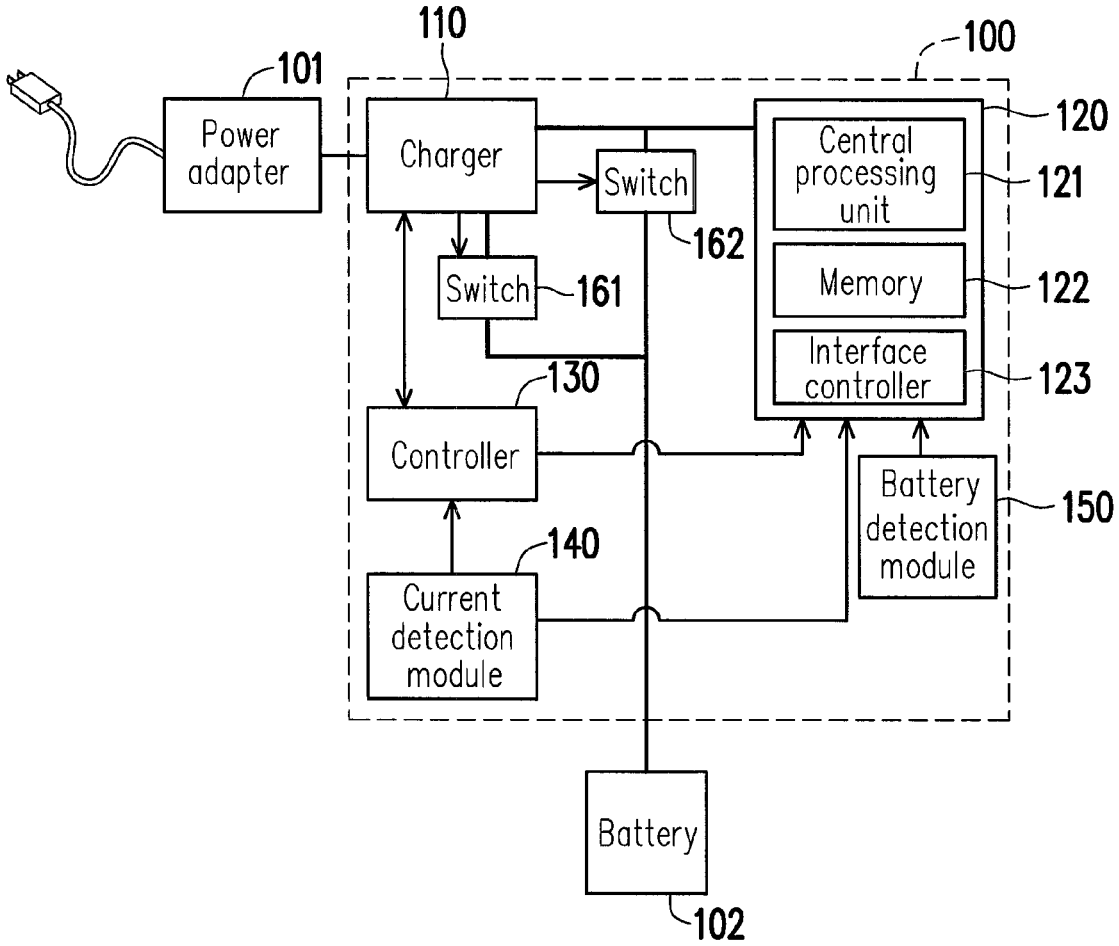
110
100
101
Power adapter
Charger
Switch
162
Switch
161
Central processing unit
120
121
Memory
122
Interface controller
123
130
Controller
Battery detection module
150
140
Current detection module
Battery
102

FIG. 1

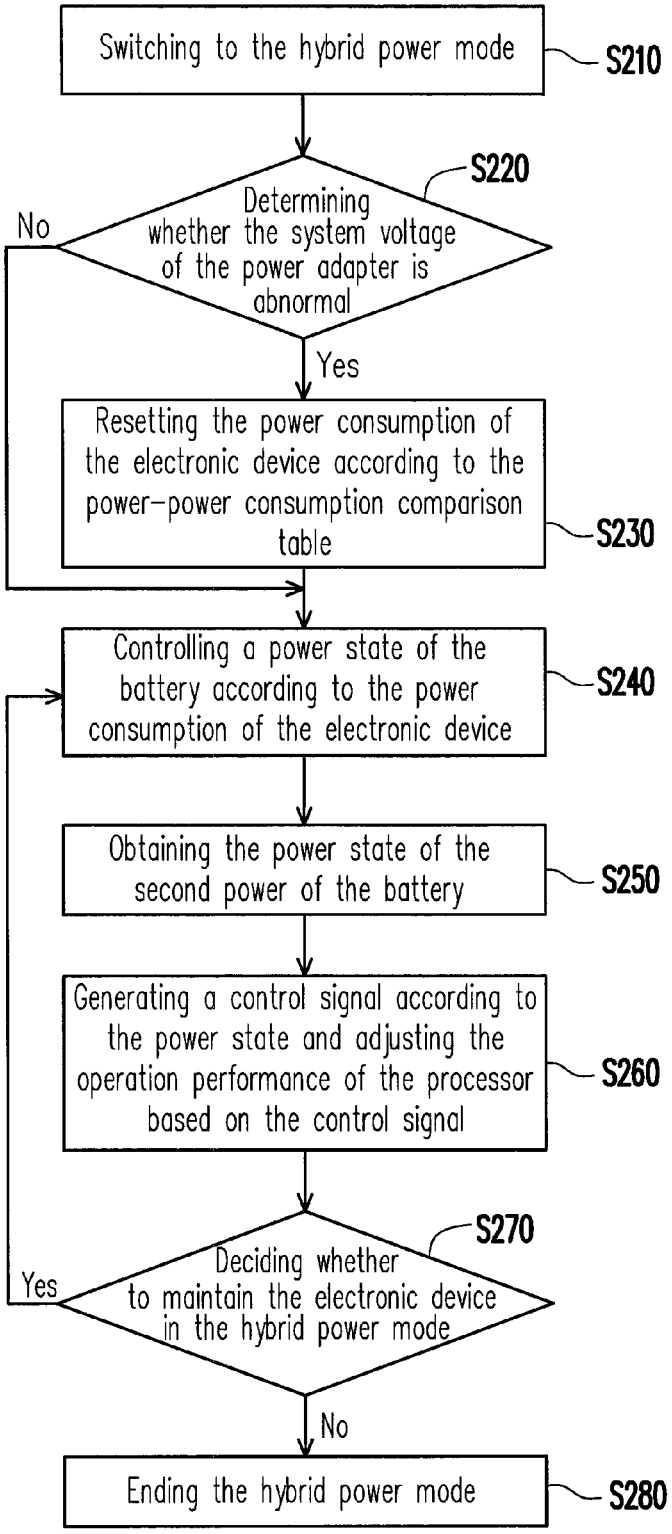
Switching to the hybrid power mode
S210
Determining whether the system voltage of the power adapter is abnormal
S220
No
Yes
Resetting the power consumption of the electronic device according to the power-power consumption comparison table
S230
Controlling a power state of the battery according to the power consumption of the electronic device
S240
Obtaining the power state of the second power of the battery
S250
Generating a control signal according to the power state and adjusting the operation performance of the processor based on the control signal
S260
Deciding whether to maintain the electronic device in the hybrid power mode
S270
Yes
No
Ending the hybrid power mode
S280

FIG. 2

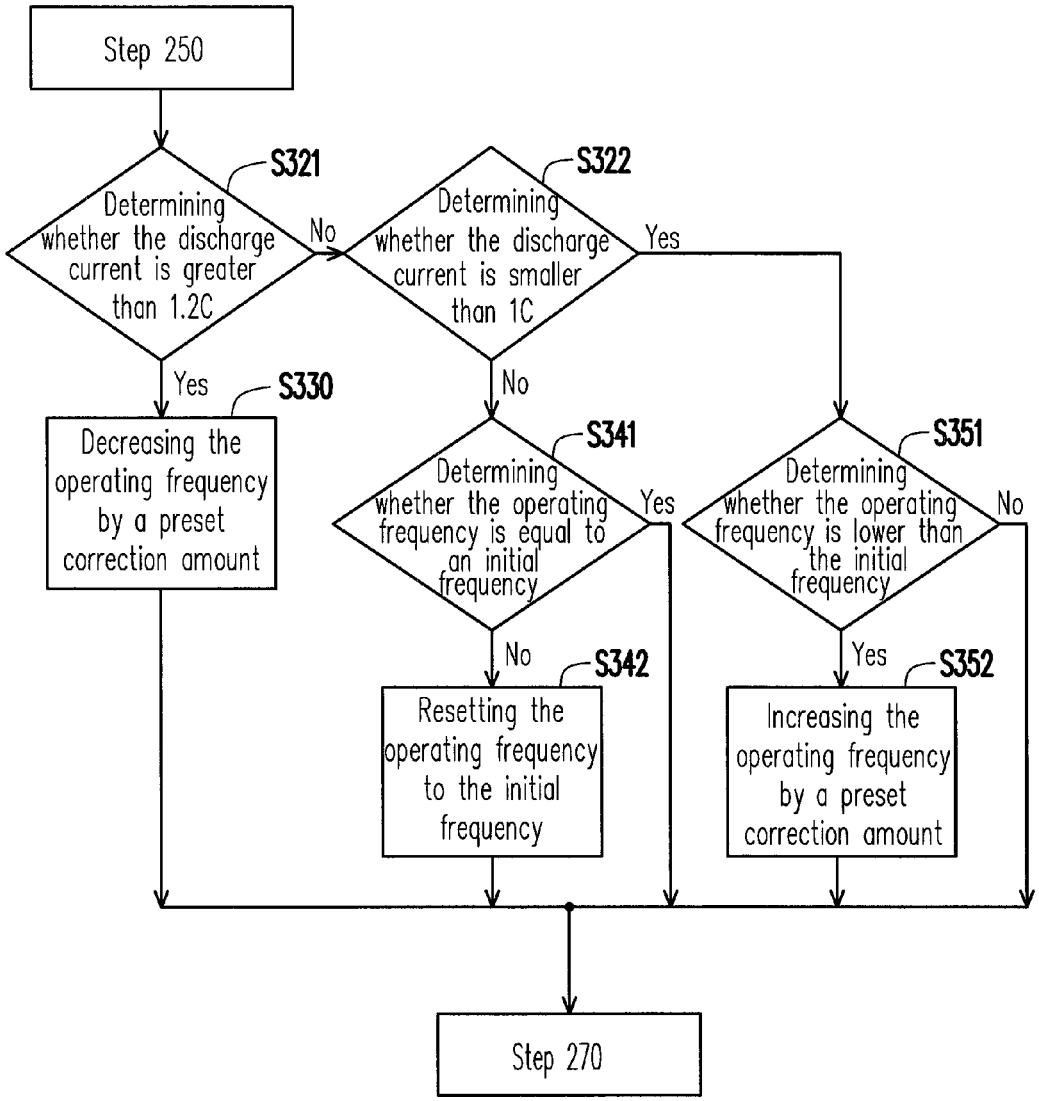
Step 250
S321
Determining whether the discharge current is greater than 1.2C
No
S322
Determining whether the discharge current is smaller than 1C
Yes
Yes
S330
Decreasing the operating frequency by a preset correction amount
No
S341
Determining whether the operating frequency is equal to an initial frequency
Yes
S351
Determining whether the operating frequency is lower than the initial frequency
No
No
S342
Resetting the operating frequency to the initial frequency
Yes
S352
Increasing the operating frequency by a preset correction amount
Step 270

FIG. 3

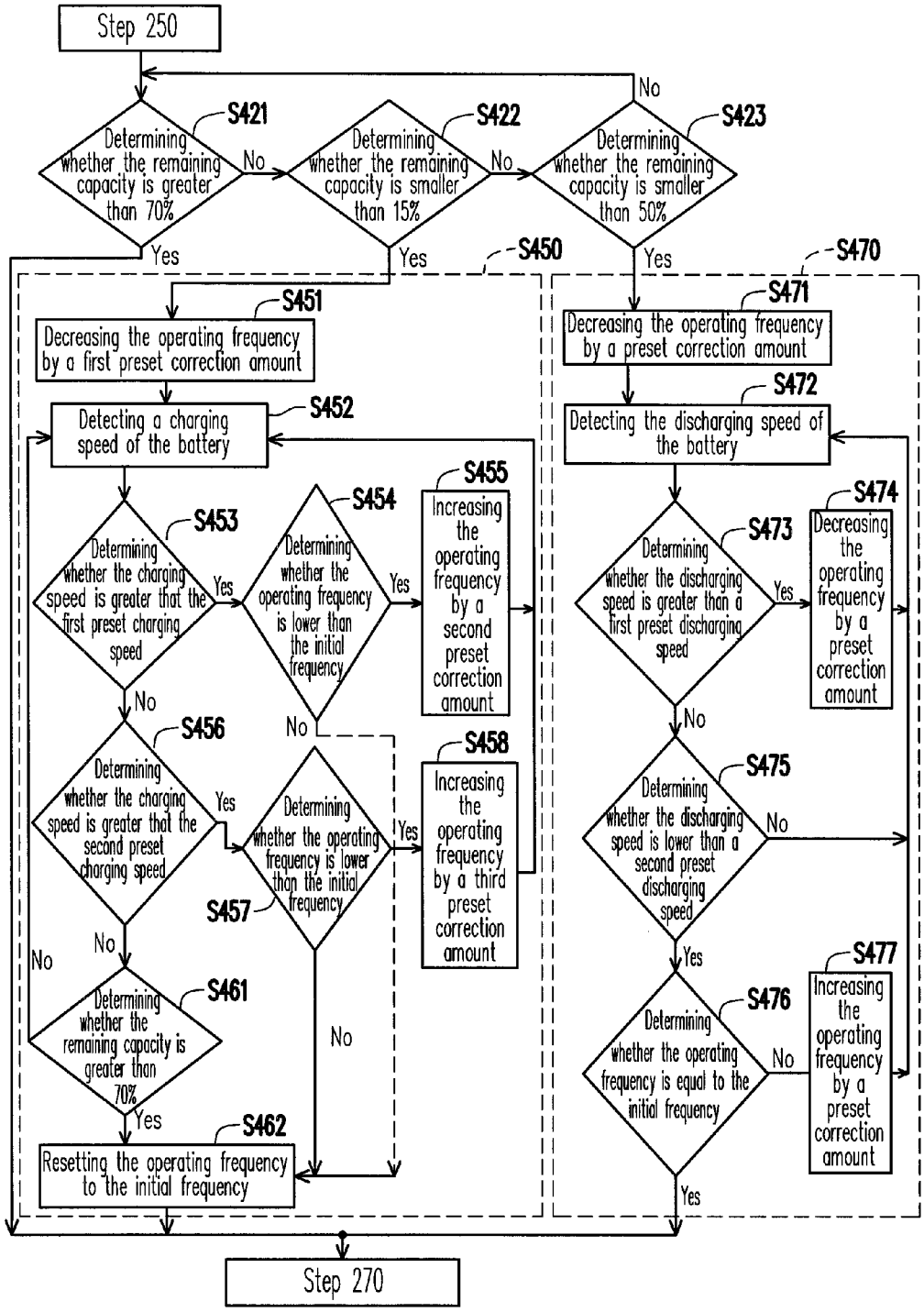
Step 250
S421
Determining whether the remaining capacity is greater than 70%
S422
Determining whether the remaining capacity is smaller than 15%
S423
Determining whether the remaining capacity is smaller than 50%
No
Yes
S450
S470
S451
Decreasing the operating frequency by a first preset correction amount
S452
Detecting a charging speed of the battery
S453
Determining whether the charging speed is greater that the first preset charging speed
S454
Determining whether the operating frequency is lower than the initial frequency
S455
Increasing the operating frequency by a second preset correction amount
S456
Determining whether the charging speed is greater that the second preset charging speed
S457
Determining whether the operating frequency is lower than the initial frequency
S458
Increasing the operating frequency by a third preset correction amount
S461
Determining whether the remaining capacity is greater than 70%
S462
Resetting the operating frequency to the initial frequency
S471
Decreasing the operating frequency by a preset correction amount
S472
Detecting the discharging speed of the battery
S473
Determining whether the discharging speed is greater than a first preset discharging speed
S474
Decreasing the operating frequency by a preset correction amount
S475
Determining whether the discharging speed is lower than a second preset discharging speed
S476
Determining whether the operating frequency is equal to the initial frequency
S477
Increasing the operating frequency by a preset correction amount
Step 270

FIG. 4

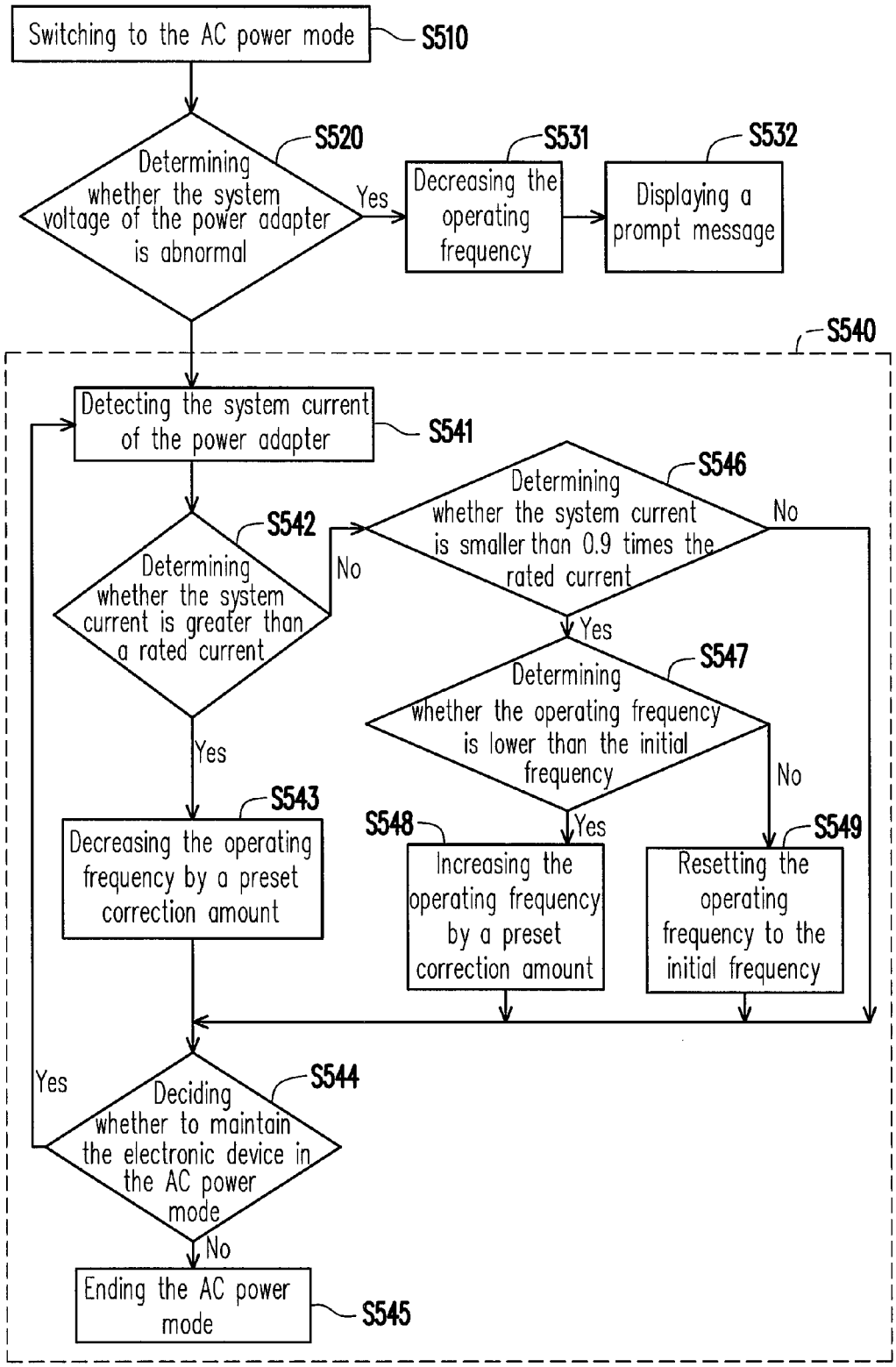
Switching to the AC power mode
S510
Determining whether the system voltage of the power adapter is abnormal
S520
Yes
Decreasing the operating frequency
S531
Displaying a prompt message
S532
S540
Detecting the system current of the power adapter
S541
Determining whether the system current is greater than a rated current
S542
No
Yes
Determining whether the system current is smaller than 0.9 times the rated current
S546
No
Yes
Determining whether the operating frequency is lower than the initial frequency
S547
No
Yes
Decreasing the operating frequency by a preset correction amount
S543
Increasing the operating frequency by a preset correction amount
S548
Resetting the operating frequency to the initial frequency
S549
Deciding whether to maintain the electronic device in the AC power mode
S544
Yes
No
Ending the AC power mode
S545

FIG. 5

# ELECTRONIC DEVICE AND POWER MANAGEMENT METHOD THEREOF

## CROSS-REFERENCE TO RELATED APPLICATION

This application claims the priority benefits of U.S. provisional application Ser. No. 61/559,200, filed on Nov. 14, 2011. The entirety of the above-mentioned patent applications is hereby incorporated by reference herein and made a part of this specification.

## BACKGROUND

Field of the Invention

The present invention is directed to an electronic device and a power management method thereof and more particularly, to an electronic device adapted to being electrically connected to a power adapter and a battery and a power management method thereof.

Description of Related Art

Typically, an electronic device may be externally connected to a power adapter to provide power by using an AC power from a wall socket. Additionally, for a user's convenience of portability and usage, the electronic device may also be provided with power through an assembled battery. In other words, most of the electronic devices currently adopt a hybrid power design that combines the AC power with the battery power for maintaining the power required by a system.

As for the hybrid power design, a sum of the charge power and the discharge power of a battery is not allowed to exceed the power provided by the power adapter so that the battery may be used for a long time. Further, when the electronic device is provided with power solely from an external AC power, a rated consumed power of the electronic device is also not allowed to exceed the power provided from the power adapter so as to avoid the electronic device from being shut down suddenly.

Therefore, how to effectively manage the power of the electronic device to prolong the run time and the cycle life of the battery as well as avoid the sudden shutdown of the system has become a major subject for the design of the electronic device.

## SUMMARY

The present invention provides a power management method for deciding whether to reset a power consumption of an electronic device in a hybrid power mode and controlling an operating frequency of the electronic device according to at least one reference frequency. Thus, the power consumption efficiency of the electronic device may be increased so that the run time and the cycle life of the battery may be prolonged.

The present invention is directed to an electronic device capable of determining whether to reset a power consumption of the electronic device according to a system voltage provided by a power adapter in a hybrid power mode so as to avoid the electronic device being shut down suddenly.

The present invention is directed to a power management method adapted to an electronic device including a controller, a processor and a battery and includes steps as follows. A first power is provided from a power adapter to the electronic device, wherein a maximum value of the first power is smaller than a maximum value of a rated consumed power required by the electronic device. A power state of a second power of the battery is obtained by using the controller. A control signal is generated according to the power state by the controller, and an operation performance of the processor is adjusted based on the control signal by the processor. The operation performance of the processor is continuously adjusted according to the power state.

The present invention is directed to an electronic device adapted to being provided with power through a power adapter and a battery, which includes a charger, a controller and a processor. The charger receives a first power provided from the power adapter to the electronic device and detects a power state of a second power of the battery, wherein a maximum value of the first power is smaller than a maximum value of a rated consumed power required by the electronic device. The controller is connected to the charger and generates a control signal according to the power state. The processor is connected to the controller to receive the control signal and adjusts an operation performance based on the control signal.

To sum up, when the electronic device of the present invention is switched to the hybrid power mode, the controller decides whether to reset the power consumption of the electronic device according to the system voltage provided by the power adapter and controls the operating frequency of the electronic device according to at least one reference frequency. Thus, even though the power adapter connected to the electronic device is a travel adaptor, the electronic device will not shut down suddenly, and the electronic device may be maintained in the normal operation by the travel adaptor and the battery. As such, the power usage efficiency of the electronic device can be improved and the rum time and the cycle life of the battery can be prolonged.

In order to make the aforementioned and other features and advantages of the present invention more comprehensible, several embodiments accompanied with figures are described in detail below.



## BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings are included to provide a further understanding of the present invention, and are incorporated in and constitute a part of this specification. The drawings illustrate embodiments of the present invention and, together with the description, serve to explain the principles of the present invention.

FIG. **1** is a schematic diagram illustrating an electronic device according to an exemplary embodiment of the present invention.

FIG. **2** is a flowchart illustrating a power management method in a hybrid power mode according to an exemplary embodiment of the present invention.

FIG. **3** is a detailed flowchart illustrating step S**260** according to an exemplary embodiment of the present invention.

FIG. **4** is a detailed flowchart illustrating step S**260** according to another exemplary embodiment of the present invention.

FIG. **5** is a flowchart illustrating a power management method in an AC power mode according to an exemplary embodiment of the present invention.

## DESCRIPTION OF EMBODIMENTS

FIG. **1** is a schematic diagram illustrating an electronic device according to an exemplary embodiment of the present invention. Referring to FIG. **1**, an electronic device **100**

includes a charger **110**, a processor **120**, a controller **130**, a current detection module **140**, a battery detection module **150**, a switch **161** and a switch **162**. Additionally, the processor **120** includes a central processing unit (CPU) **121**, a memory **122** and an interface controller **123**. The CPU **121** is mainly responsible for various types of logical operations and program executions. The memory **122** is configured to store various types of data. The interface controller **123** is configured to coordinate input and output of the processor **120**. Besides, the controller **130** may be, for example, an embedded controller, and the processor **120** may be, for example, a central processor or a display card processor.

Moreover, the electronic device **100** may be provided with power through the power adapter **101** and/or the battery **102**. For instance, the power adapter **101** has a first power and is capable of providing the first power to the electronic device **100**. A maximum value of the first power provided by the power adapter **101** is smaller than a maximum value of a rated consumed power of the electronic device **100**. Additionally, the battery **102** has a second power and is capable of providing a second power to the electronic device **100**. In other words, power supply states for the electronic device **100** include three modes, i.e. a hybrid power mode (the electronic device **100** is provided with power by both the power adapter **101** and the battery **102**), an AC power mode (the electronic device **100** is provided with power solely by the power adapter **101**) and a battery power mode (the electronic device **100** is provided with power solely by the battery **102**). In addition, in different power supply states, the charger **110** controls the power provided to the processor **120** by adjusting conducting states of the switches **161** and **162**. Further, the electronic device **100** analyzes and detects the power supply states of the electronic device **100** through the controller **130**, the current detection module **140** and the battery detection module **150**.

FIG. **2** is a flowchart illustrating a power management method in a hybrid power mode according to an exemplary embodiment of the present invention. Referring to FIG. **2** with FIG. **1** hereinafter, detailed operation of the electronic device **100** in the hybrid power mode will be illustrated. In step S**210**, when the electronic device **100** is provided with power by the power adapter **101** and the battery **102**, the electronic device **100** is switched to the hybrid power mode and is provided with power by using the first power and the second power simultaneously. In the hybrid power mode, the power adapter **101** converts AC power to generate a system voltage and a system current for the electronic device **100** to use.

In addition, the charger **110** detects and records the system voltage and the system current provided by the power adapter **101** and reports the system voltage and the system current to the controller **130**. Further, in step S**220**, the controller **130** further determines whether the system voltage provided by the power adapter **101** is abnormal. When a level of the system voltage does not stop shaking or drifting up and down, it represents that the system voltage is abnormal. At this time, the controller **130** determines that the first power of the power adapter **101** is smaller than a power consumption of the electronic device. Namely, for the electronic device **100**, the power adapter **101** at this time is equivalent to a travel adapter.

In order to avoid a sudden shutdown of the electronic device **100** due to being externally connected to the travel adapter, as shown in step S**230**, when the controller **130** determines that the system voltage is abnormal, the controller **130** looks up a power-power consumption comparison table and resets the power consumption of the electronic device **100** according to a look-up result.

For example, at the beginning, in an initialization of the electronic device **100**, the controller **130** regards the power adapter **101** as a standard adapter. Thus, the controller **130** sets the power consumption of the electronic device **100** according to a configuration (e.g. a CPU level, existence of an independent display card) of the electronic device **100**. For instance, the power consumption is set as 65 W. However, when the system voltage is abnormal, the controller **130** determines that the power adapter **101** is a travel adapter and thus, resets the power consumption of the electronic device **100** according to the power-power consumption comparison table. For instance, the power consumption is reset as 30 W so as to decrease an operation performance of the processor **120**. As such, the electronic device **100** will not be shut down suddenly due to being externally connected to the travel adapter.

Moreover, in step S**240**, the charger **110** controls a power state of the battery **102** according to the power consumption of the electronic device **100**. For example, when the power consumption is smaller than the power provided by the charger, it represents that there is additional power available for charging the battery **102**. Thus, at this time, the charger **110** switches the power state of the battery **102** to a charging mode by controlling the conducting states of the switches **161** and **162**. Otherwise, when the power consumption is greater than the power provided by the charger, the charger **110** switches the power state of the battery **102** to a discharging mode.

Accordingly, if the original power consumption of the electronic device **100** is 65 W, the electronic device **100** still may be provided with power by the power adapter **101** which has the first power of 45 W and the battery **102**. Namely, even though the electronic device **100** is externally connected to the travel adapter, the electronic device **100** is not shut down suddenly, and the electronic device **100** may be maintained in normal operation by the hybrid use of the travel adapter and the battery. On the other hand, if the system voltage is not abnormal, it represents that the power adapter **101** externally connected to the electronic device **100** is a standard adaptor, and thus, at this time, the controller **130** does not reset the power consumption of the electronic device **100**.

Moreover, the charger **110** detects a power state of the second power provided by the battery **102**. In addition, in step S**250**, the electronic device **100** obtains the power state of the second power which is provided by the battery **102** through the controller **130**. Further, in step S**260**, the electronic device **100** adjusts the operation performance of the processor **120** according to the power state of the battery **102**. For instance, the controller **130** generates a control signal according to the obtained power state, and the processor **120** adjusts the operation performance based on the control signal. Furthermore, in an exemplary embodiment, the operation performance of the processor **120** may be, for example, a clock frequency of the processor **120**, and the clock frequency of the processor **120** may be, for example, an operating frequency of the CPU **121** in the electronic device **100**. Moreover, in step S**270**, the controller **130** further determines whether the electronic device **100** is electrically connected to the power adapter **101** and the battery **102** simultaneously to decide whether to maintain the electronic device **100** in the hybrid power mode.

Here, if the electronic device **100** is continuously maintained in the hybrid power mode, then step S**240** is returned to, and the power state of the battery **102** is continuously

controlled, and by steps S**250** and S**260**, the operation performance of the processor **120** is continuously adjusted. Namely, when the electronic device **100** is continuously maintained in the hybrid power mode, the electronic device **100** keeps adjusting the operation performance of the processor **120** according to the power state of the battery **102**. Accordingly, the power of the electronic device **100** may be effectively managed so as to prolong the run time and cycle life of the battery **101**. Oppositely, if one of the power adapter **101** and the battery **102** is electrically disconnected from the electronic device **100**, the controller **130** perform step S**280** so as to end the hybrid power mode.

It is to be mentioned that the power state of the battery **102** may be, for example, a discharge current, a remaining capacity or the like of the battery **102**. In other words, in step S**260**, the electronic device **100** may adjust the operation performance of the processor **120** by using the discharge current or the remaining capacity of the battery **102**. In order to enable persons of ordinary skill in the art to understand the exemplary embodiment of the present invention, step S**260** will be described in more detail.

FIG. **3** is a detailed flowchart illustrating step S**260** according to an exemplary embodiment of the present invention. Hereinafter, please refer to FIG. **3** with FIG. **1**. In operation, the charger **110** detects the discharge current of the battery **102** and reports the detected discharge current to the controller **130**. Additionally, the controller **130** determines a value of the discharge current by using a first threshold current (e.g. 1.2 C) and a second threshold current (e.g. 1 C). Namely, the controller **130** compares the discharge current of the battery **102** with the first threshold current and the second threshold current respectively.

For instance, in step S**321**, the controller **130** determines whether the discharge current is greater than the first threshold current (e.g. 1.2 C). If not, in step S**322**, the controller **130** further determines whether the discharge current is smaller than the second threshold current (e.g. 1 C). As a result, the controller **130** may determine that the discharge current is greater than the first threshold current (e.g. 1 C), between the first threshold current (e.g. 1.2 C) and the second threshold current (e.g. 1 C), or smaller than the second threshold current (e.g. 1 C).

When the discharge current is greater than the first threshold current (e.g. 1 C), in step S**330**, the controller **130** transmits a corresponding control signal to the processor **120**, such that the processor **120** decreases the operating frequency of the CPU **121** by a preset correction amount based on the control signal. That is, the operating frequency of the CPU **121** at this time is decreased by a preset correction amount so that the operation performance of the processor **120** is decreased.

When the discharge current is between the first threshold current (e.g. 1.2 C) and the second threshold current (e.g. 1 C), in step S**341**, the controller **130** determines in advance whether the operating frequency of the CPU **121** is equal to an initial frequency. If yes, the operating frequency of the CPU **121** is not updated. Otherwise, if the operating frequency is not equal to the initial frequency, in step S**342**, the controller **130** transmits the corresponding control signal to the processor **120**, such that the processor **120** resets the operating frequency of the CPU **121** to the initial frequency based on the control signal. Meanwhile, it is know that the initial state of the processor **120** is to maintain the operating frequency of the CPU **121** in the initial frequency. In other words, when the discharge current is between the first threshold current (e.g. 1.2 C) and the second threshold current (e.g. 1 C), the electronic device **100** adjusts the operation performance of the processor **120** to the initial state.

Moreover, when the discharge current is smaller than the second threshold current (e.g. 1 C), in step S**351**, the controller **130** determines in advance whether the operating frequency is lower than the initial frequency. If not, the operating frequency of the CPU **121** is not updated. Otherwise, if the operating frequency of the CPU **121** is lower than the initial frequency, that is, the operation performance of the processor **120** is lower than the initial state, in step S**352**, the controller **130** transmits the corresponding the control signal to the processor **120**. Thus, the processor **120** increases the operating frequency of the CPU **121** by a preset correction amount based on the control signal. Namely, the operating frequency at this time is increased by a preset correction amount so that the operation performance of the processor **120** is increased.

In other words, when the discharge current of the battery **102** exceeds the first threshold current (e.g. 1.2 C), the operation performance of the processor **120** is decreased so as to decrease the discharge current of the battery **102**. Additionally, when the discharge current of the battery **102** is between the first threshold current (e.g. 1.2 C) and the second threshold current (e.g. 1 C), the operation performance of the processor **120** is adjusted to the initial state. Further, when the discharge current is smaller than the second threshold current (e.g. 1 C), and the operation performance of the processor **120** is lower than the initial state, the operation performance of the processor **120** is increased, such that the discharge current of the battery **102** is increased. Accordingly, defects of over-current and over-temperature occurring in the battery **102** may be avoided.

FIG. **4** is a detailed flowchart illustrating step S**260** according to another exemplary embodiment of the present invention. Please refer to FIG. **4** with FIG. **1** hereinafter. In operation, the charger **110** detects a remaining capacity of the battery **102** and reports the detected remaining capacity to the controller **130**. In addition, the controller **130** determines a value of the remaining capacity by using a first reference capacity (e.g. 70%), a second reference capacity (e.g. 50%) and a third reference capacity (e.g. 15%). Namely, the controller **130** compares the remaining capacity of the battery **102** with the first reference capacity, second reference capacity and the third reference capacity respectively.

For instance, in step S**421**, the controller **130** determines whether the remaining capacity is greater than the first reference capacity (e.g. 70%). If not, in step S**422**, the controller **130** further determines whether the remaining capacity is smaller than the third reference capacity (e.g. 15%). And, if not, the controller **130** further determines whether the remaining capacity is smaller than the second reference capacity (e.g. 50%). Thus, the controller **130** may determine that the remaining capacity is greater than the first reference capacity (e.g. 70%), smaller than the third reference capacity (e.g. 15%) or between the second reference capacity (e.g. 50%) and the third reference capacity (e.g. 15%).

When the remaining capacity is greater than the first reference capacity (e.g. 70%), the operation performance of the processor **120** is not adjusted and step S**270** is directly performed. Further, when the remaining capacity is smaller than the third reference capacity (e.g. 15%), in step S**450**, the electronic device **100** adjusts the operation performance of the processor **120** according to a charging speed of the battery **102**. Namely, the controller **130** generates a control

signal according to the charging speed of the battery **102**, such that the processor **120** adjusts the operation performance based on the control signal. Regarding the detailed process of step S**450**, as shown in step S**451**, the controller **130** transmits a corresponding control signal to the processor **120** to enable the processor **120** to decrease the operating frequency of the CPU **121** by a first preset correction amount. For instance, if the processor **120** adjusts the operating frequency of the CPU **121** by a unit of correction amount, the operating frequency of the CPU **121** is decreased by four times the unit of correction amount, such that the operation performance of the processor **120** is drastically decreased.

Afterward, in step S**452**, the charger **110** detects a charging speed of the battery **102** and reports the detected charging speed to the controller **130**. In addition, the controller **130** determines a value of the charging speed of the battery **102** by using a first preset charging speed (e.g. increasing 12% of the battery capacity per 30 minutes) and a second preset charging speed (e.g. increasing 6% of the battery capacity per 30 minutes). Namely, the controller **130** compares the charging speed of the battery **102** with the first preset charging speed and the second preset charging speed respectively.

For instance, in step S**453**, the controller **130** determines in advance whether the charging speed of the battery **102** is greater that the first preset charging speed. As shown in step S**454** and step S**455**, when the charging speed of the battery **102** is greater than the first preset charging speed, and the operating frequency of the CPU **121** is lower than the initial frequency (i.e. the operation performance of the processor **120** is lower than the initial state), the processor **120** increases the operating frequency of the CPU **121** by a second preset correction amount. For example, the operating frequency of the CPU **121** is increased by twice the unit of correction amount, so that the performance of the operation performance of the processor **120** is increased for two levels of energy efficiency. Meanwhile, after increasing the operating frequency, step S**452** is returned to, and the operating frequency of the CPU **121** is continuously updated according to the charging speed of the battery **102**. Otherwise, if the operating frequency is determined as not lower than the initial frequency in step S**454**, step S**462** is returned to, and the operating frequency of the CPU **121** is reset to the initial frequency.

Moreover, as shown in step S**457** and step S**458**, when the charging speed of the battery **102** is between the first preset charging speed and the second preset charging speed, and the operating frequency of the CPU **121** is lower than the initial frequency (i.e. the operation performance of the processor **120** is lower than the initial state), the processor **120** increases the operating frequency of the CPU **121** by a third preset correction amount. For example, the operating frequency of the CPU **121** is increased by one unit of correction amount, such that the operation performance of the processor **120** is increased for one level of energy efficiency. Further, after increasing the operating frequency, step S**452** is returned to, and the operating frequency of the CPU **121** is continuously updated according to the charging speed of the battery **102**. Otherwise, if the operating frequency is determined as not lower than the initial frequency in step S**457**, step S**462** is returned to.

Moreover, when the charging speed of the battery **102** is lower than the second preset charging speed, in step S**461**, the controller **130** determines whether the remaining capacity of the battery **102** is greater than the first reference capacity (e.g. 70%). When the remaining capacity of the battery **102** is not greater than the first reference capacity (e.g. 70%), the controller **130** returns to step S**452** to continue to detect the charging speed of the battery **102**. Additionally, when the remaining capacity of the battery **102** is greater than the first reference capacity (e.g. 70%), step S**462** is returned to, and the operating frequency of the CPU **121** is reset to the initial frequency.

In other words, when the remaining capacity of the battery **102** is smaller than the third reference capacity (e.g. 15%), the electronic device **100** first drastically decreases the operation performance of the processor **120** (for example, directly decreases the operating frequency of the CPU **121** for four times the preset correction amount) and then, successively increases the operation performance of the processor **120** according to the charging speed of the battery **102**. Thus, when the remaining capacity of the battery **102** is too small, the defect of crash occurring in the electronic device **100** may be avoided.

Continuously referring to FIG. **4** with FIG. **1**, when the remaining capacity is between the second reference capacity (e.g. 50%) and the third reference capacity (e.g. 15%), in step S**470**, the electronic device **100** adjusts the operation performance of the processor **120** according to a discharging speed of the battery **102**. Regarding the detailed process of step S**470**, as shown in step S**471**, the controller **130** transmits a corresponding control signal to the processor **120** so as to enable the processor **120** to decrease the operating frequency of the CPU **121** by a preset correction amount. Namely, the operating frequency of the CPU **121** at this time is decreased for a preset correction amount, such that the operation performance of the processor **120** is decreased for one level of energy efficiency. Afterward, in step S**472**, the charger **110** detects the discharging speed of the battery **102** and reports the detected discharging speed to the controller **130**. Meanwhile, the controller **130** determines a value of the discharging speed of the battery **102** by using a first preset discharging speed (e.g. decreasing 6% of the battery capacity per 30 minutes) and a second preset discharging speed (e.g. decreasing 4% of the battery capacity per 30 minutes). Namely, the controller **130** compares the discharging speed of the battery **102** with the first preset discharging speed and the second preset discharging speed respectively.

For instance, in step S**473**, the controller **130** determines in advance whether the discharging speed of the battery **102** is greater than the first preset discharging speed. When the discharging speed of the battery **102** is greater than the first preset discharging speed, in step S**474**, the controller **130** transmits a corresponding control signal to the processor **120** to enable the processor **120** to decrease again the operating frequency of the CPU **121** by a preset correction amount. Afterward, step S**472** is returned to, and the operating frequency of the CPU **121** is continuously updated according to the discharging speed of the battery **102**. When the discharging speed of the battery **102** is not greater than the first preset discharging speed, in step S**475**, the controller **130** determines whether the discharging speed of the battery **102** is lower than the second preset discharging speed. When the discharging speed of the battery **102** is not lower than the second preset discharging speed, step S**472** is returned to. Further. as shown in step S**476** and step S**477**, when the discharging speed of the battery **102** is lower than the second preset discharging speed, and the operating frequency of the CPU **121** is not equal to the initial frequency (i.e. the operation performance of the processor **120** is not in the initial state), the processor **120** increase the operating frequency of the CPU **121** by a preset correction amount, such

that the operation performance of the processor **120** is increased for one level of energy efficiency.

In other words, when the remaining capacity of the battery **102** is between the second reference capacity (e.g. 50%) and the third reference capacity (e.g. 15%), the electronic device **100** successively decreases or increases the operation performance of the processor **120** according to the discharging speed of the battery **102**. Thereby, when the battery **102** is overly used, the operation time of the battery **102** may be prolonged.

It is to be mentioned that when being switched to the battery power mode, the electronic device **100** also adjusts the operation performance of the processor **120** according to the power state of the battery. In the battery power mode, the electronic device **100** adjusts detailed operations of the operation performance of the processor **120** according to the power state of the battery, which is similar to the operation process of step S**260** in FIG. **2**. Therefore, the detailed operations regarding the electronic device **100** in the battery power mode will not be repeated.

FIG. **5** is a flowchart illustrating a power management method in an AC power mode according to an exemplary embodiment of the present invention. Hereinafter, referring to FIG. **5** with FIG. **1**, detailed operations of the electronic device **100** in the AC power mode is illustrated. In step S**510**, when the electronic device **100** is provided with power only from the power adapter **101**, i.e. the electronic device **100** is provided with power only by using the first power of the power adapter **101**, the electronic device **100** is switched to the AC power mode. In the AC power mode, the power adapter **101** converts the AC power to a corresponding system voltage and a corresponding system current for the electronic device **100** to use.

In addition, the charger **110** detects and records the system voltage and the system current provided by the power adapter **101** and reports the system voltage and the system current to the controller **130**. Further, in step S**520**, the controller **130** further determines whether the system voltage provided by the power adapter **101** is abnormal. When the system voltage is abnormal, in step S**531**, the controller **130** transmits a corresponding control signal to the processor **120** so as to enable the processor **120** to decrease the operating frequency of the CPU **121**. Namely, the operation performance of the processor **120** at this time is decreased. Meanwhile, in step S**532**, the controller **130** displays a prompt message. Therein, the content of the prompt message may be, for example, "The power provided form the power adapter is insufficient, please insert a battery". Thus, the sudden shutdown of the electronic device **100** may be avoided, and by prompting the user to insert the battery through the prompt message, the electronic device **100** may be switched into the hybrid power mode in response to the insertion of the battery.

When the system voltage is not abnormal, in step S**540**, the controller **130** adjusts the operation performance of the processor **120** according to the system current of the power adapter **101**. Regarding the detailed process of step S**540**, as shown in step S**541**, the charger **110** detects and records the system current provided by the power adapter **101** and reports the system current to the controller **130**. Further, in step S**542**, the controller **130** determines whether the system current is greater than a rated current.

When the system current is greater than the rated current, in step S**543**, the processor **120** is controlled by the controller **130** to decrease the operating frequency of the CPU **121** by a preset correction amount. Namely, under the control of the controller **130**, the operation performance of the processor **120** at this time is decreased for one level of energy efficiency. Afterward, in step S**544**, the controller **130** determines whether the electronic device **100** is electrically connected to the power adapter **101** and electrically disconnected to the battery **102** so as to decide whether to maintain the electronic device **100** in the AC power mode. If the electronic device **100** is maintained in the AC power mode, step S**541** is returned to, and operation performance of the processor **120** is continuously adjusted according to the system current of the power adapter **101**. Otherwise, when the controller **130** and the power adapter **101** are electrically disconnected to each other, the controller **130** performs step S**545** to end the AC power mode accordingly.

When the system current is not greater than the rated current, in step S**546**, the controller **130** further determines whether the system current is smaller than 0.9 times the rated current. When the system current is not smaller than 0.9 times the rated current, step S**544** is returned to. When the system current is not smaller than 0.9 times the rated current, in step S**547**, the controller **130** further determines whether the operating frequency of the CPU **121** is lower than the initial frequency. Afterward, in step S**548**, when the operating frequency of the CPU **121** is lower than the initial frequency, the processor **120** increases the operating frequency of the CPU **121** by a preset correction amount. Namely, the operation performance of the processor **120** is increased for one level of energy efficiency. Otherwise, when the operating frequency of the CPU **121** is not lower than the initial frequency, in step S**549**, the processor **120** resets the operating frequency of the CPU **121** to the initial frequency. That is, the operation performance of the processor **120** at this time is decreased for one level of energy efficiency.

Continuously referring to FIG. **1**, it is to be mentioned that the battery detection module **150** detects whether the electronic device **100** is electrically connected to the battery **102**. When detecting that the electronic device **100** is electrically disconnected from the battery **102**, the battery detection module **150** immediately transmits an interrupt signal to the processor **120**. Further, in the hybrid power mode, the processor **120** switches the operating frequency of the CPU **121** to a lowest operating frequency within a buffer time since the interrupt signal is received. Namely, the operation performance of the processor **120** at this time is decreased down to a lowest performance. Thereby, in the hybrid power mode, even though the battery **102** is suddenly plugged out, the electronic device **100** will not be shut down suddenly.

Additionally, the current detection module **140** detects that a current variation (i.e. a variation of the system current) of the first power provided by the power adapter **101**, and when the current variation is greater than a threshold value, the current detection module **140** immediately transmits an interrupt signal to the processor **120** and the controller **130**. Besides, in the AC power mode, the processor **120** switches the operating frequency of the CPU **121** to a lowest operating frequency within a buffer time since the interrupt signal is received. Namely, the operation performance of the processor **120** at this time is decreased down to a lowest performance. Thereby, in the AC power mode, even though the power adapter **101** provides large current in an instant, the electronic device **100** is still maintained in operation.

In view of the foregoing, when the electronic device exemplarily illustrated in the present invention is switched to the hybrid power mode, the controller decides whether to reset the power consumption of the electronic device according to the system voltage provided by the power adapter. Thus, even though the power adapter connected to the

electronic device is a travel adapter, the electronic device will not be shut down suddenly. Further, in the hybrid power mode, when the electronic device is externally connected to the travel adapter, the electronic device may also be maintained in normal operation by the hybrid of the travel adaptor and the battery. As such, the power usage efficiency of the electronic device can be improved and the rum time and the cycle life of the battery can be prolonged accordingly.

Although the invention has been described with reference to the above embodiments, it will be apparent to one of the ordinary skill in the art that modifications to the described embodiment may be made without departing from the spirit of the invention. Accordingly, the scope of the invention will be defined by the attached claims not by the above detailed descriptions.

What is claimed is:

**1**. A power management method, applicable to an electronic device comprising a controller, a processor and a battery, the power management method comprising:

in a hybrid power mode, providing a first power to the electronic device by a power adapter and providing a second power to the electronic device by the battery, wherein a maximum value of the first power is smaller than a maximum value of a rated consumed power required by the electronic device;

providing the electronic device with power through the first power and the second power simultaneously;

when the electronic device is provided with power through the first power and the second power simultaneously, decreasing a clock frequency of the processor in response to determining that a system voltage of the power adapter is abnormal;

in response to decreasing the clock frequency of the processor, obtaining a discharge current or a remaining capacity of the battery in the electronic device provided with power through the first power and the second power simultaneously;

generating a control signal according to a power state of the second power by the controller and adjusting the clock frequency of the processor by the processor based on the control signal; and

continuously adjusting the clock frequency of the processor according to the power state of the second power of the battery.

**2**. The power management method according to claim **1**, wherein the controller is an embedded controller.

**3**. The power management method according to claim **1**, wherein the processor is a central processor or a display card processor.

**4**. The power management method according to claim **1**, further comprising:

in the hybrid power mode, when the system voltage of the power adapter is abnormal, determining that the first power is smaller than a power consumption required by the electronic device and resetting the power consumption required by the electronic device according to a power-power consumption comparison table.

**5**. The power management method according to claim **4**, wherein the step of resetting the power consumption required by the electronic device comprising:

decreasing an operation performance of the processor.

**6**. The power management method according to claim **1**, wherein the power state is the discharge current of the battery, and the step of adjusting the clock frequency of the processor based on the control signal comprise:

comparing the discharge current with a first threshold current and a second threshold current respectively so as to adjust an operation performance of the processor, wherein the first threshold current is greater than the second threshold current;

when the discharge current is greater than the first threshold current, decreasing the operation performance of the processor;

when the discharge current is between the first threshold current and the second threshold current, adjusting the operation performance of the processor to an initial state; and

when the discharge current is smaller than the second threshold current, and the operation performance of the processor is lower than the initial state, increasing the operation performance of the processor.

**7**. The power management method according to claim **1**, wherein the power state is the remaining capacity of the battery and the step of adjusting the clock frequency of the processor based on the control signal comprise:

comparing the remaining capacity with a first reference capacity, a second reference capacity and a third reference capacity respectively so as to adjust an operation performance of the processor, wherein the first reference capacity is greater than the second reference capacity, and the second reference capacity is greater than the third reference capacity;

when the remaining capacity is greater than the first reference capacity, not adjusting the operation performance of the processor;

when the remaining capacity is smaller than the third reference capacity, adjusting the operation performance of the processor according to a charging speed of the battery; and

when the remaining capacity is between the second reference capacity and the third reference capacity, adjusting the operation performance of the processor according to a discharging speed of the battery.

**8**. The power management method according to claim **7**, wherein the step of adjusting the operation performance of the processor according to the charging speed of the battery comprise:

decreasing the operation performance of the processor by a first preset correction amount;

detecting the charging speed of the battery;

comparing the charging speed with a first preset charging speed and a second preset charging speed respectively so as to adjust the operation performance of the processor, wherein the first preset charging speed is greater than the second preset charging speed;

when the charging speed is greater than the first preset charging speed, and the operation performance of the processor is lower than an initial state, increasing the operation performance of the processor by a second preset correction amount;

when the charging speed is between the first preset charging speed and the second preset charging speed, and the operation performance of the processor is lower than the initial state, increasing the operation performance of the processor by a third preset correction amount; and

when the charging speed is lower than the second preset charging speed, and the remaining capacity of the battery is not greater than the first reference capacity, returning to the step of detecting the charging speed of the battery.

9. The power management method according to claim 7, wherein the step of adjusting the operation performance of the processor according to the discharging speed of the battery comprise:

decreasing the operation performance of the processor by a preset correction amount;

detecting the discharging speed of the battery;

comparing the discharging speed with a first preset discharging speed and a second preset discharging speed respectively so as to adjust the operation performance of the processor, wherein the first preset discharging speed is greater than the second preset discharging speed;

when the discharging speed is greater than the first preset discharging speed, decreasing the operation performance of the processor by the preset correction amount and returning to the step of detecting the discharging speed of the battery;

when the discharging speed is between the first preset discharging speed and the second preset discharging speed, returning to the step of detecting the discharging speed of the battery; and

when the discharging speed is lower than the second preset discharging speed, and the operation performance of the processor is not in an initial state, increasing the operation performance of the processor by the preset correction amount and returning to the step of detecting the discharging speed of the battery.

10. The power management method according to claim 1, further comprising:

in an AC power mode, providing power to the electronic device only by using the first power.

11. The power management method according to claim 10, further comprising:

in the AC power mode, when the system voltage of the power adapter is abnormal, decreasing an operation performance of the processor and displaying a prompt message; and

in the AC power mode, when the system voltage is not abnormal, adjusting the operation performance of the processor according to a system current of the power adapter.

12. The power management method according to claim 1, wherein the electronic device further comprises:

a battery detection module, configured to detect whether the electronic device is electrically connected to the battery and transmit an interrupt signal to the processor to decrease an operation performance of the processor down to a lowest performance when detecting that the electronic device is electrically disconnected from the battery.

13. The power management method according to claim 1, wherein the electronic device further comprises:

a current detection module, configured to detect a current variation of the first power provided by the power adapter and transmit an interrupt signal to the processor to decrease an operation performance of the processor down to a lowest performance when detecting that the current variation is greater than a threshold value.

14. An electronic device, adapted to be provided with power through a power adapter and a battery, the electronic device comprising:

a charger, receiving a first power provided from the power adapter to the electronic device, wherein the first power has a maximum value that is smaller than a maximum value of a rated consumed power required by the electronic device, and the electronic device is provided with power through the first power and a second power of the battery simultaneously in a hybrid power mode;

a processor; and

a controller, connected to the charger and the processor, wherein when the electronic device is provided with power through the first power and the second power of the battery simultaneously, the controller decreases a clock frequency of the processor in response to determining that a system voltage of the power adapter is abnormal,

in response to decreasing the clock frequency of the processor, the charger detects a discharge current or a remaining capacity of the battery in the electronic device provided with power through the first power and the second power simultaneously, the controller generates a control signal according to a power state of the second power, and the processor adjusts the clock frequency based on the control signal.

15. The electronic device according to claim 14, wherein the controller is an embedded controller.

16. The electronic device according to claim 14, wherein the processor is a central processor or a display card processor.

17. The electronic device according to claim 14, wherein in the hybrid power mode, when the system voltage of the power adapter is abnormal, the controller determines that the power provided by the power adapter is smaller than a power consumption required by the electronic device and resets the power consumption according to a power-power consumption comparison table, wherein a method to reset the power consumption of the electronic device is to decrease an operation performance of the processor.

18. The electronic device according to claim 14, wherein when the power state is the discharge current of the battery, the controller compares the discharge current with a first threshold current and a second threshold current respectively so as to adjust an operation performance of the processor, wherein the first threshold current is greater than the second threshold current.

19. The electronic device according to claim 18, wherein

when the discharge current is greater than the first threshold current, the processor decrease the operation performance based on the control signal,

when the discharge current is between the first threshold current and the second threshold current, the processor adjusts the operation performance to an initial state based on the control signal, and

when the discharge current is smaller than the second threshold current, and the operation performance of the processor is lower than the initial state, the processor increases the operation performance based on the control signal.

20. The electronic device according to claim 14, wherein when the power state is the remaining capacity of the battery, the controller compares the remaining capacity with a first reference capacity, a second reference capacity and a third reference capacity respectively so as to adjust an operation performance of the processor wherein the first reference capacity is greater than the second reference capacity, and the second reference capacity is greater than the third reference capacity.

21. The electronic device according to claim 20, wherein

when the remaining capacity is greater than the first reference capacity, the processor does not adjust the operation performance based on the control signal,

when the remaining capacity is smaller than the third reference capacity, the controller generates the control

signal according to a charging speed of the battery so as to adjust the operation performance based on the control signal, and

when the remaining capacity is between the second reference capacity and the third reference capacity, the controller generates the control signal according to a discharging speed of the battery so as to adjust the operation performance.

**22**. The electronic device according to claim **21**, wherein when the remaining capacity is smaller than the third reference capacity, the processor decreases the operation performance by a preset correction amount and successively increases the operation performance according to the charging speed of the battery.

**23**. The electronic device according to claim **21**, wherein when the remaining capacity is between the second reference capacity and the third reference capacity, the processor decreases the operation performance by a preset correction amount and successively decreases or increases the operation performance according to the discharging speed of the battery.

**24**. The electronic device according to claim **14**, wherein when the electronic device is provided with power only through the power adapter, and the system voltage of the power adapter is abnormal, the processor decreases an operation performance under the control of the controller, and the controller displays a prompt message.

**25**. The electronic device according to claim **14**, wherein when the electronic device is provided with power only through the power adapter, and the system voltage of the power adapter is not abnormal, the controller generates the control signal according to a system current of the power adapter so as to control an operation performance of the processor.

**26**. The electronic device according to claim **14**, wherein the electronic device further comprises a battery detection module which is configured to detect whether the electronic device is electrically connected to the battery and transmit a interrupt signal to the processor to decrease an operation performance of the processor down to a lowest performance when detecting that the electronic device is electrically disconnected from the battery.

**27**. The electronic device according to claim **14**, wherein electronic device further comprises a current detection module which is configured to detect a current variation of the first power provided by the power adapter and transmit an interrupt signal to the processor to decrease an operation performance of the processor down to a lowest performance when detecting that the current variation is greater than a threshold value.

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